

PERFORMANCE OF BOTTOM ASH TREATED
PEAT SOIL IN IMPROVING BEARING
CAPACITY

SONIA SINGGAR AK LEMBANG

B. ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG



SUPERVISOR'S DECLARATION

I/We* hereby declare that I/We* have checked this thesis/project* and in my/our* opinion, this thesis/project* is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

(Supervisor's Signature)

Full Name : DR. YOUVENTHARAN DUR AISAMY

Position : SENIOR LECTURER

Date :



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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

(Student's Signature)

Full Name : SONIA SINGGAR AK LEMBANG

ID Number : AA14217

Date :

PERFORMANCE OF BOTTOM ASH TREATED PEAT SOIL IN IMPROVING
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SONIA SINGGAR AK LEMBANG

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DEDICATION

To my beloved family for all support and love

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ABSTRAK

Tanah gambut dengan kekuatan ricih rendah, kebolehmampatan tinggi dan kandungan air permulaan yang tinggi, dianggap tidak sesuai untuk proses pembinaan. Oleh itu, campuran tanah dengan Simen Portland Biasa (OPC) adalah salah satu kaedah yang biasa digunakan untuk merawat tanah gambut. Walau bagaimanapun, disebabkan kos yang tinggi kaedah ini masih bukan kaedah terbaik yang disyorkan untuk tujuan ini. Dalam industri loji kuasa, abu bawah (Bottom Ash) dianggap bahan sisa dengan tempat untuk dilupuskan dan tiada nilai guna semula. Kajian terdahulu menunjukkan campuran abu bawah dengan serbuk simen dijangka dapat menstabilkan tanah gambut dengan mengubah sifat semula jadi. Kajian ini bertujuan untuk mengkaji kapasiti galas dan indeks kumpulan tanah gambut tropika yang stabil di Pantai Timur Semenanjung Malaysia dengan mencampurkan sebahagian simen OPC yang sama dan pelbagai abu bawah. Juga kajian ini akan membincangkan tingkah laku tanah gambut dengan atau tanpa abu bawah dan penstabilan simen. Sebahagian tetap pengikat OPC dan pelbagai bahagian abu bawah (bahan pozzolanic) dalam satu siri ujian makmal telah dijalankan. Semua sampel telah mengalami 3 hari direndam dalam pengalaman air untuk sampel direndam. Sampel tak terbakar telah diuji selepas pencampuran. Peningkatan kapasiti galas sedang dinilai menggunakan ujian California Bearing Ratio (CBR). Keputusan menunjukkan bahawa selepas mencampurkan dengan abu bawah kapasiti galas peningkatan tanah gambut dengan meningkatkan peratusan abu bawah dalam tanah gambut.

ABSTRACT

Peat soil with low shear strength, high compressibility and high initial water content, is deemed unsuitable for construction process. Hence soil mixing with Ordinary Portland Cement (OPC) is one of the methods commonly used to treating the peat soil. However due to high cost this method is still not the best method recommended for this purpose. In power plant industry bottom ash considered waste material with nowhere to dispose and no reuse value. Previous research shows bottom ash mix with cement powder is expected to stabilise the peat soil by changing its natural properties. This research aims to study the bearing capacity and group index of stabilized tropical peat soil of East Coast of Peninsular Malaysia by mixing same proportion of OPC cement and various proportion of bottom ash. Also this study will discuss the behaviour of peat soil with or without the bottom ash and cement stabilization. A fixed proportion of OPC binders and various proportion of bottom ash (pozzolanic material) in a series of laboratory test were conducted. All samples have undergone 3 days soaked in water experience for soaked sample. Unsoaked sample was tested after mixing. The improvement in bearing capacity was being evaluated using California Bearing Ratio (CBR) test. The results shows that after mixing with bottom ash the bearing capacity of peat soil increase with increase the bottom ash percentage in peat soil.

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LIST OF SYMBOLS

MW	Mega watt
ha	Hectare
%	Percentage
km ²	Kilometre square
mm	millimetre
N	North
E	East
°	Degree
m	Meter
ml	Millilitre
kN-m/m ³	Kilonewton- meter per meter cube
Kg/m ²	Kilogram per meter square
m/s	Meter per second
cm	centimetre
kN/m ³	Kilonewton per meter cube
cm ³	Centimetre cube
g	Gram
m ²	Meter square
cm ²	Centimetre square
cm/s	Centimetre per second
g/cm ³	Gram per centimetre cube
kg	kilogram

LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
Al ₂ O ₃	Aluminium Oxide
ASTM	American Standard Test Method
BA	Bottom Ash
BaO	Barium oxide
BS	British Standard
CaO	Calcium Oxide
CBA	Coal Bottom Ash
CBR	California Bearing Ratio
C _c	Coefficient of Curvature
C _u	Coefficient of Uniformity
DMM	Dry Mixed Method
DMJ	Dry Jet Mixing
ESA	Equivalent Standard Axles
FA	Fly Ash
JKR	Jabatan Kerja Raya
K ₂ O	Potassium Oxide
LL	Liquid Limit
MDD	Maximum Dry Density
MgO	Magnesium Oxide
Na ₂ O	Sodium Oxide
OMC	Optimum Moisture Content
PA	Pond Ash
P ₂ O ₅	Phosphorus Pentoxide
PI	Plasticity Index
PL	Plastic Limit
RHA	Rick Husk Ash
SEM	Scanning Electron Microscopy
SiO ₂	Silicon Dioxide
SO ₃	Sulphur Trioxide
TiO ₂	Titanium Dioxide
UCS	Unconfined Compression Strength
USCS	Unified Soil Classification System
XRF	x-ray fluorescence

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Peat soil contains a high amount of decomposed and disintegrated plant remains under condition of incomplete aeration and high water content. Around the world there are 400 million ha of peat soil. In Malaysia there are some 3 million ha covered in peat. Table 1.1 shows the proportion of peat soil in Malaysia.

Table 1.1 : Proportion of peat soil in Malaysia (Jon Davies et al., 2010)

State	Area (ha)
Peninsular	642 918
Sabah	111 965
Sarawak	1697 847

Peat soil has unfavourable characteristic such as low bearing capacity, low specific gravity, medium to low permeability, high compressibility, high content of natural water, high water holding capacity, high rates of creep and difficult accessibility (Venuja et al., 2017)

When using peat soil for construction, problem such as instability, slip failure, localized sinking and long term settlement (Venuja et al., 2017) will occur and therefore it is very difficult to use. However due to increase in population and scarcity

of good land for development, peat soil is in demand for construction purpose. Generally there are two ways to improve peat soil i) mechanical method and ii) chemical method. It depends on the engineer's justification or sometimes on client's budget to choose the best method to improve peat. Some will cut and replace the peat, others will treat the soil or just completely avoid from using the soil for construction (which is not the best option). Typically mechanical method consists of 'cut and fill' method, stage construction, preloading, stone columns, piles, vertical drains and lightweight fill and as for chemical method there are deep in-situ mixing and surface stabilization had been introduced to improved expansive soil (clay, peat soil, etc). Among all deep soil mixing is one of the commonly used methods for soil stabilization. This in- situ method involves mechanically mixing of cementitious compound like Ordinary Portland Cement or lime.

For centuries coal has been used as one of the most important energy sources. Approximately 40% of electricity production in the worldwide is based on coal. In Malaysia, 7 of its power plant use coal as a raw material in generating electricity since the year 1988. Table 1.2 shows summarizes of capacity coal power plant in Malaysia.

Table 1.2: Summarizes the capacity of coal powered plant in Malaysia (Marto & Tan, 2016).

Power plant	Commissioning year	Capacity (MW)
Jimah, Negeri Sembilan	2009	1400
Manjung, Perak	2002	2295
Kapar, Selangor	1988	2420
Tanjung Bin, Johor	2006	2100
Mukah, Sarawak	2009	270
PPLS, Sarawak	2006	110
Sejingkat, Sarawak	1997	100

From these power plants Fly ash (FA) and Bottom ash (BA) are generated as one of the waste product. Fly ash has been used in cement industry meanwhile there are still some doubts on how to utilize bottom ash in the industry. Previous studies show that the bottom ash is highly potential in the construction industry as an alternative to existing materials. Therefore to check and validate the benefit involving bottom ash, this research is mainly focused to improve peat soil properties. Bottom ash will work with pozzolanic material in the soil mixing method. Using OPC as the binder, there will be a pozzolanic reaction when these two substances mixed together. In this study, 5% of OPC (binder) and 5% to 20% of Bottom ash was used to mix tropical peat soil.

1.2 PROBLEM STATEMENT

Due to its low shear strength, high compressibility and high initial water content, peat soil is unsuitable for construction process (Venuja et al., 2017). Therefore it is best to avoid because of the instability and settlement problem occurrence if any structures are to be built on it. However due to increasing in development and population, demand of land used for construction is unavoidable. Thus various method and solution are suggested to improve and strengthen peat soil properties. Previous researcher comes with many ways that can be categorized into two

- i. Mechanical method
- ii. Chemical method

Some of approaches are highly costly and the effectiveness is still questionable. So in order to find the best method, these factors should be considered

- Environmental friendliness
- Cost
- Effectiveness
- Reliability and durability

Mechanical method like cut and replace involve too much time and costly makes many reluctant to choose this method. While chemical method such as deep mixing stabilization appears to be cheap, but it is not very environmental friendly.

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